

HOW IT WORKS

MIMO

MIMO technology significantly boosts data transfer speeds over wireless networks using multiple antennas. Tom Royal explains three different MIMO systems that could set the standard for the future

Wireless networking has changed the way that many of us use computers in our homes. Rather than having one computer full of documents that can only be carried around on a floppy disk, you can easily store files on one PC, use them on another and send them to the office over a broadband internet connection – all from the comfort of the sofa.

But wireless networks have suffered from one big problem: bandwidth. Most modern desktop PCs can communicate over a network cable at 1Gbit/s. The fastest wireless networking standard, 802.11g, can transfer data at a theoretical maximum speed of 54Mbit/s. Some manufacturers have produced equipment that increases transfer speeds to 100, 108 and even 125Mbit/s, but even this is not fast enough to stream high-quality video files reliably.

In our recent Complete Guide to Wireless (*Shopper*, September 2005) we tested several products that use new technology to provide the best wireless transfer speeds we've ever seen. This speed boost is created using several aerials and a technique called Multiple-In, Multiple-Out, or MIMO for short.

OFF THE WALL

MIMO products use more than one antenna to send several different streams of data between the two ends of a wireless connection. When using a standard wireless network connection, you do not need a clear line of sight between your computer and router, as the radio signal can reflect off walls and other objects. These reflections can pass around obstacles, extending the area covered by your network. Unfortunately, some areas can prove out of range to both the original signal and its reflections. If you place a computer in one of these dead spots, you won't be able to connect to the network.

MIMO helps by increasing the number of radio beams and consequently the number of reflections. By using multiple antennas, spaced slightly apart from one another, and several beams of data, the areas covered by the original radio broadcasts and by reflections are increased. This decreases the number of dead spots that aren't covered by any radio broadcasts. Having multiple beams is particularly useful in houses, where wireless signals need to pass through doors and down corridors. In our Complete Guide to Wireless, the Linksys WRT54GX router provided a signal to a computer 10m and several rooms away that was faster than the signal it provided to a computer one metre away. Every non-MIMO router lost some of its transfer speed over this distance, with several decreasing by over 50 per cent.

In most homes, upgrading to MIMO requires a new router with several aerials and a new network card for each computer. Unfortunately, not all MIMO products are compatible. The 802.11n standard for wireless networking, which will almost certainly include MIMO, is some way from completion. To bridge the gap between 802.11g and future products, several manufacturers have introduced proprietary MIMO systems. The three most common at present are Airgo's True MIMO, Video54's BeamFlex and Atheros's AR5005VL VLocity. These systems are very different, so we'll consider each in turn.

AIRGO TRUE MIMO

Airgo's True MIMO system is used by the *Shopper* Best Buy award-winning Linksys WRT54GX, Belkin's Pre-N products and Buffalo's MIMO range. It uses a technique called spatial multiplexing to send data between several antennas.

Spatial multiplexing involves sending different data streams on the same frequency but through different paths from different antennas. The data to be sent is split into several different data streams by a Digital Signal Processor, or DSP. Each stream is then passed through a radio transceiver and to an aerial. Most current systems using True MIMO split the data into three, then pass it to three separate transceivers and to three antennas.

At the other end of the wireless connection the three data streams are received by three antennas, then recombined into the original data. With three transceivers and three sets of antennas at each end, True MIMO requires a large number of components

to implement. Some have suggested that True MIMO is less compatible with 802.11g devices than its rivals, but Morikazu Sano, senior VP of global marketing at Buffalo Technology, disputes this. He told *Shopper* that True MIMO is "one hundred per cent compatible with 802.11b and 802.11g".

True MIMO devices have performed extremely well in our tests. The Linksys WRT54GX produced transfer speeds of up to 17.3Mbit/s in our 10m test, where its nearest rival managed only 10.8Mbit/s.

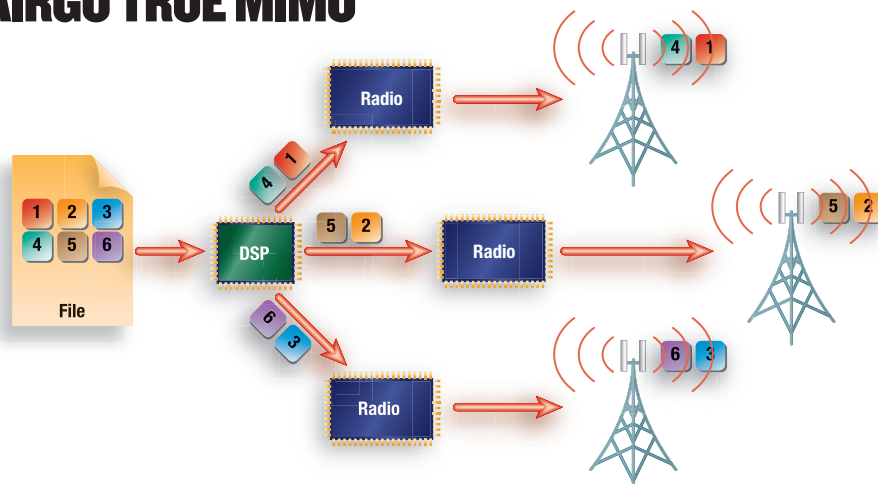
VIDEO54 BEAMFLEX

Video54's BeamFlex MIMO system, as used in Netgear's RangeMax wireless products, is radically different. It uses more antennas than Airgo's system; in fact Netgear's WPN824 router uses seven. Unlike the Airgo True MIMO router, these antennas are not all connected to individual radio transceivers. Rather than dividing the data into multiple streams, BeamFlex sends one single data stream to one antenna at any given time. It relies on rapidly switching between antennas to always provide the best path to the data's destination. A small computer processor inside the BeamFlex router chooses which aerial to use to send each packet, basing this on its experience when sending previous packets.

Whether this system is actually MIMO or not is disputed. Buffalo's Morikazu Sano told *Shopper*: "To meet the definition of MIMO, a device must be transmitting over more than one radio. Video54's technology uses one radio with a beam-steering antenna. Thus it does not qualify as MIMO." Netgear's Mark Power disputed this, adding that



AIRGO TRUE MIMO



▲ Airgo's True MIMO system splits the data to be sent into several streams. Each stream is passed through a separate radio transceiver to a separate antenna



the Spatial Multiplexing technique used by Airgo "is only one way to realise MIMO".

MIMO or not, the BeamFlex system has several advantages. For one, its use of just one radio transceiver makes it less complicated to make than products using Airgo's True MIMO. Netgear told us it "can deliver [BeamFlex] at much lower costs than alternative technologies that require more complex PCB designs and more components. Essentially, [it] offers much greater value for money."

BeamFlex requires special hardware on only one end of the radio connection. To use Airgo's spatial multiplexing system requires three antennas and three transceivers on each end of the wireless connection. BeamFlex requires special technology only at the router. In fact, Netgear's WPN511 RangeMax Cardbus network adaptor is physically identical to many 802.11g Super-G 108Mbit/s network adaptors. When we asked Netgear why this product costs around £20 more than the similar WG511T, we were told the company had "optimised the software drivers so the WPN511 will work best with the WPN824 router".

In our tests, however, BeamFlex was underwhelming. Netgear's WPN824 BeamFlex product gave slower transfer speeds than the Airgo-based Linksys WRT54GX in every one of the tests performed for our Complete Guide to Wireless. Over 25m, it was just 0.1Mbit/s behind, but when running at distances of 1m and 10m it was over 5Mbit/s slower than its rival. Its performance when connected to a standard Centrino network adaptor was poorer. Netgear told us it considered BeamFlex more compatible with non-MIMO 802.11g devices than Airgo's True MIMO, but our results suggest that Airgo's system produces faster transfers to non-MIMO products. The Airgo-based router produced transfer speeds averaging 12.6Mbit/s to a Centrino adaptor, where Netgear's WPN824 averaged 8.2Mbit/s.

ATHEROS AR5005VL

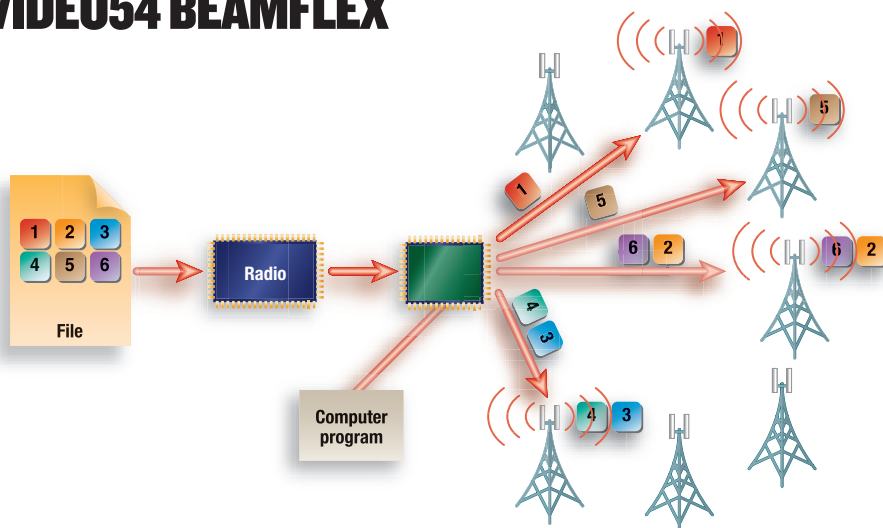
Atheros Communications is best known for its Super-G wireless network products. These chips, used in products such as Netgear's WPN511, increase bandwidth in non-MIMO networks by using frame bursting, a technique used in wired Gigabit Ethernet where several packets are sent at once, and channel bonding. Channel bonding involves using two of the 11 wireless networking channels at once. It is effective at increasing data throughput, but is considered by some to be a 'bad neighbour' as it has been known to affect the performance of other networks running nearby. The AR5005VL chipset adds to these methods by using two radio transceivers and two antennas.

Like BeamFlex, the AR5005VL system does not use spatial multiplexing. Instead, the same data is sent to both transceivers and both aerials. So far, only D-Link has launched consumer products using the AR5005VL. A spokesperson told us the Atheros system was "25 per cent faster than the Airgo solution in an all-MIMO network". We hope to test this claim in future reviews.

THE Nth DEGREE

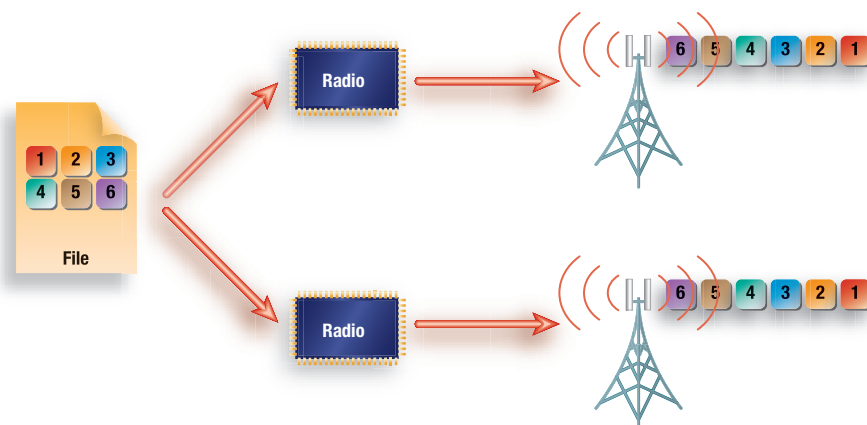
Given these three competing systems and the prospect of more on the horizon, the future for MIMO looks confusing. It's almost certain that one form of MIMO will form the basis for the 802.11n standard, but it's not clear when a draft of this specification will be ready to work from. Some

VIDEO54 BEAMFLEX



▲ Video54's BeamFlex system uses several antennas but only one radio transceiver. An embedded computer program decides which antenna is the best to use when sending each packet

ATHEROS AR5005VL VLOCITY



▲ The Atheros AR5005VL chipset uses two radio transceivers and two antennas. The data to be sent is passed through both transceivers and both antennas simultaneously

manufacturers have decided to wait until the standard is nearer before launching any MIMO products. Broadcom's Henry Rael told *Shopper* it "intends to maintain and expand its competitive position in the WiFi chip market [and] we believe this is best achieved by delivering a standards-compliant product that is interoperable".

The wait for 802.11n has been increased by a division within the body responsible for agreeing such standards. For the past year, the Institute of Electrical and Electronics Engineers, or IEEE, has been split into two camps, with each demanding a different approach to 802.11n. One group, WWiSE, represents companies such as Airgo, Broadcom, HP, Siemens, Buffalo, Nokia and Motorola. It advocates using MIMO in an open-loop system, where multiple antennas send out data to multiple receiving antennas, but with no feedback as to which antenna is performing best. This system requires the use of only one wireless network channel.

Its rival, TGn Sync, is supported by Agere, Cisco, Intel, Philips, Samsung and VIA. It proposes a closed-loop system, where the receiving device sends back information on which antennas are performing best. Armed with this information, the sending

device can dedicate more power to the best-performing aerials and cut back on the power supplied to those encountering interference. This system, as one would expect from a group that includes Agere Communications, relies on channel bonding.

At the time of writing, neither side had gained a majority sufficient to turn its proposal into the basis of a draft 802.11n specification. Instead, the two agreed that a compromise would need to be created to prevent deadlock, though no such option has yet been published. Netgear's Mark Power told us that 802.11n "ratification is estimated to be in the autumn of 2007", but that a draft "could be voted for and defined as early as Q1 or Q2 [January to June] 2006".

Once such a draft is released, it's likely that manufacturers will standardise on the MIMO system it sets out and that one or all of the technologies will become obsolete. Meanwhile, if you want a fast wireless network to send video files, MIMO equipment is a good, though expensive, way of setting one up. If you want a network that will be compatible with new 802.11n products into 2006 and 2007, though, it's worth waiting a little longer. **CS**